CHAPTER 10

Remedies and Innovative Technologies

10-1. Introduction. This chapter addresses remedies and innovative technologies that may be used at radioactive remediation sites. There are only a few remedies available at sites contaminated with radioactive materials: attenuation through decay, decontamination of soils, buildings, and equipment, and disposal of the contaminant, or disposal of the contaminated soils, buildings or equipment. There are a number of potential disposal sites addressed in Chapter 12. In this chapter we will limit our discussion to disposal on-site and disposal off-site.

10-2. Attenuation through Decay. This can only prove feasible when the half-lives of all the radioactive contaminants are short enough for the attenuation to occur within a specified time. For example, if a site is contaminated with I-125, which has a 60-day half-life, attenuation could be considered as a means of accomplishing remediation. Within 2 years, 99.9% of the I-125 will have decayed away. However, attenuation would not be feasible at a site contaminated with uranium, which has a 4 billion year half-life.

10-3. Decontamination. This is the process of removing some or all of a radioactive contaminant from an object. For a procedure to be feasible, it must be able to remove enough of the radioactive material so that the object can pass a final status survey. Decontamination has been attempted on soils using soil-washing techniques. Results have been mixed because of varying soil parameters that may bind the contaminants to the soil, or make the soil handling difficult.

10-4. Soil Volume Reduction. This has been attempted using a number of processes. Segmented gate systems operate using an array of detectors positioned over a conveyor belt. The soils are loaded onto the conveyor belt in a thin layer, and passed under the detectors. When a detector senses some radioactive material in the soil, that particular portion of soil is diverted out of the waste stream into a contaminated material pile. The rest of the soil goes on to the 'clean' pile. A USACE pilot study results can be found at http://www.fusrapmaywood.com/Docs/MISS-106.pdf.

10-5. Soil Washing. The soil-washing process is a treatment method where dispersed, low-level radioactive contaminated particles are washed from the soil fraction. Low to intermediate levels of contamination are removed from the soil. The process can reduce the volume of a contaminated soil that would otherwise require special handling and packaging for off-site disposal by 98%. Soil can be washed in situ or ex situ and is done using a dilute solvent that is selective for the contaminants to be treated. Soil washing may be effective when there is an inverse relationship between particle size and contaminant concentration. Soil washing is effective for the remediation of soils with a high content of material with

large particle sizes (more than 90% sand and gravel). After size separation, a large portion of the radioactive material may be concentrated in the fine material, leaving a minor portion in the coarse material. The coarse material may then contain low enough amounts of radioactive material for replacement on-site. Soil washing has been successfully demonstrated (pilot scale) on soils contaminated with strontium, cesium, technetium, radium, uranium, thorium, barium, and lead. Soil washing can also be used for mixed wastes contaminated with organics or heavy metals. One problem with soil washing has been stakeholder acceptance of using the washed soil as fill at the site. Some pilot studies for chemical extraction methods can be found at:
http://www.frtr.gov/matrix2/section3/table3_8.html.

10-6. In-situ Phytoremediation. This is a method of using plants to bioaccumulate contaminants. It has been able to remove approximately 95% of the cesium and strontium contamination from a pond near Chernobyl, where sunflowers were grown hydroponically, and to remove uranium from water. Indian mustard and poplar trees have also been used. The plants take up certain contaminants and store them within their biomass. Most accumulation is in the root system, which may make it less amenable to soil remediation. Similarly, DOE research has shown promise in using bioaccumulation of uranium from soil matrices by certain bacteria.

10-7. Ex-situ Soil Treatment. The ex-situ soil treatment process combines dissolution with dilute selective solvents, contaminant recovery, and solvent regeneration to provide a continuous recirculating treatment process. The solvent chemistry combines well-established carbonate recovery chemistry with a chelant and an oxidant. Countercurrent extraction is used to dissolve and recover the contaminant in the ex-situ treatment process. The number of extraction stages and the contact time in the extractors are determined based on the contamination level in the soil, the physical and chemical characteristics of the soil, and the level to which the soil must be treated. Removal factors (the ratio of the contaminant level in the feed material divided by the contaminant level in the treated material) of 10 to 20 are typically achievable.

10-8. Equipment and Debris. Waste may be compacted to reduce its volume. First, one should determine whether compaction is beneficial to the treatment and disposal scheme of each waste. Compaction may be an appropriate technology to reduce disposal costs if the disposal facility charges on a volume basis. If debris will be sent off-site for disposal, it is important to determine if the disposal facility has any dimensional limitations on debris. Land disposal facilities sometimes limit dimensions to ensure proper compaction during placement in the disposal cell.

10-9. Cutting and Sawing. These operations may be appropriate on large metal or plastic items. This type of waste typically has to be reduced to make it fit into packaging containers or to prepare it for further treatment, such as incineration. The cutting may be carried out either in the dry state in cells, and with conventional tools, or underwater. The cutting may also be done with plasma-jets, laser torches, or explosive fuses. Crushing techniques may be used for size reduction of friable solids (e.g., glass, concrete, and ceramics). Crushing increases the apparent density of the waste. In principle, all types of mill, grinder, and crushing machines of conventional technology can be used. Shredding reduces void space and is particularly effective when plastics are compacted. Air, trapped between the folds of bulk plastic and in plastic bags, takes up container and disposal space.

10-10. Incineration. Incineration as a hazardous waste treatment technology is discussed in EM 1110-1-502. Major considerations in using incinerator technology for radioactive waste treatment involve shielding requirements, use of HEPA filters, and methods of ash disposal. Incineration is primarily a volume reduction technique. It has a secondary benefit of destroying hazardous organic chemicals often present in mixed waste. In all instances, incineration will create a final product, which is ash, with a higher radionuclide concentration. This ash may require treatment before disposal.

10-11. Building Demolition.

a. Demolition is the total destruction of a building, structure, or piece of equipment. Demolition usually occurs in conjunction with dismantling. Specific demolition techniques include complete burn-down, controlled blasting, wrecking with balls or backhoe-mounted rams, rock splitting, awing, drilling, and crushing. The debris may be treated (possibly by incineration) and is then disposed of. The building is usually pretreated for the majority of the radioactive material before demolition, and some structures within the building may have to be dismantled and removed before demolition.

b. Hazardous substances, such as PCBs and asbestos, may also be present in the building and typically warrant prior remediation or removal so as to avoid generating large quantities of commingled waste (TSCA or NESHAP regulated) during the building demolition. Contaminated structures and equipment can be physically separated from the environment by a barrier. These barriers may be plaster, epoxy resins, or concrete. Control effectiveness depends primarily on the correct choice of encapsulant.

10-12. Hydroblasting. This technique uses a high-pressure (3500- to 350,000-kPa), low volume water jet to remove contaminated debris from surfaces. The debris and water are collected, and the water is decontaminated. Hydroblasting may not effectively remove contaminants that have penetrated the surface layer. On the average, this technique removes 0.5 to 1.0 centimeters of concrete surface at the rate of 35 m^2/hr. The method can be used on contaminated concrete, brick, metal, and other materials. Hydroblasting can easily incorporate variations such as hot or cold water, abrasives, solvents, surfactants, and varied pressures.

10-13. Paint Removal. This might be needed in a building found to contain radioactive contamination on the wall surface or trapped between layers of paint. A combination of commercial paint removers, hand scraping, water washing, and detergent scrubbing may be necessary to remove the paint and radioactive contamination. Fixative/stabilizer coatings can be used on contaminated residues to fix or stabilize the contaminant in place and decrease or eliminate exposure hazards. These agents include molten and solid waxes, carbowaxes, organic dyes, epoxy paint films, gels, foams, and polyester resins. To create strippable coatings, compounds that bind with contaminants are mixed with a polymer, applied to a contaminated surface, and removed to achieve decontamination.

10-14. Scarification. This is capable of removing up to 2.5 centimeters of surface layer from concrete (not block) and cement. The scarifier tool consists of pneumatically operated piston heads that strike the surface, causing concrete to chip off. The piston heads consist of multipoint tungsten carbide bits. An almost identical or similar process to scarifying is scabbling, in which a super-high-pressure water system can be used. This water system is more easily operated remotely. Wall, floor, and hand-held scarifiers are available.

10-15. Steam. Steam cleaning physically extracts contaminants from building materials and equipment surfaces. Currently, steam cleaning is used mainly to remove contaminated particulate. This technique is known to be effective only for surface decontamination. Steam cleaning requires steam generators, spray systems, collection sumps, and waste treatment systems. Commercial-scale steam cleaners are available from many manufacturers. Several manufacturers make portable steam cleaning equipment.

10-16. Drilling and Spalling. This operation consists of drilling holes 2.5 to 4 centimeters in diameter and 7.5 centimeters deep into concrete. The spalling tool bit is inserted into the hole and hydraulically spreads to spall off the contaminated concrete. This technique can remove up to 5 centimeters of surface from concrete or similar materials. Vacuum filter systems and water sprayers can be used to control dust during drilling and spalling operations. Remotely operated drill and span rigs are available.

10-17. Disposal. Disposal may be accomplished through a number of methods. Burial and capping on-site, disposal at waste disposal facilities, and allowed effluent releases are the most common methods of disposal. AR 11-9 prohibits on-site burial at DA facilities, and on-site burial rarely will be allowed without site restrictions or institutional controls of some type.